TEXTON-BASED DIAGNOSIS OF ALZHEIMER'S DISEASE

Pedro M. Morgado*, Margarida Silveira*, Durval C. Costa†‡
and the Alzheimer's Disease Neuroimaging Initiative

* Instituto Superior Técnico, Institute for Systems and Robotics, Lisbon, Portugal.
† Nuclear Medicine, Champalimaud Clinical Center, Champalimaud Foundation, Lisbon, Portugal. ‡ HPP Medicina Molecular, SA, Porto, Portugal.
Contacts: pedromorgado@isr.ist.utl.pt, msilveira@isr.ist.utl.pt

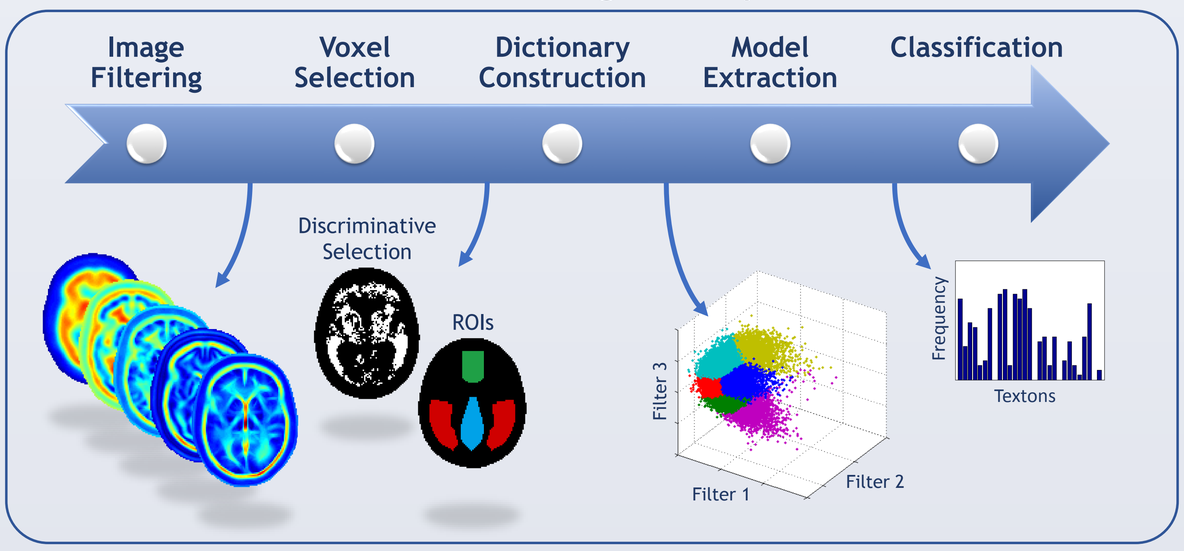
INTRODUCTION

Alzheimer's disease (AD) is the most common form of dementia and its early detection (still at the Mild Cognitive Impairment (MCI) stage) is essential to improve patients' life quality and extend life expectancy. Previous studies, such as [1], showed that the texture of FDG-PET images contains discriminative information about these conditions (AD and MCI).

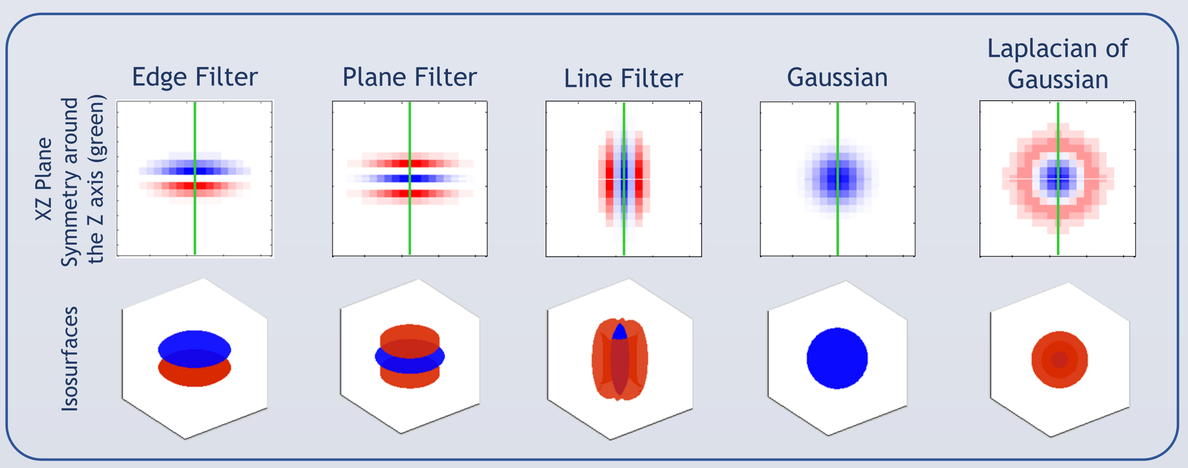
In this work, we explore two different methods for the automated diagnosis of AD and MCI based on the VZ classifier proposed by Varma and Zisserman [2]. The first approach conducts a discriminative selection of the filter responses used for dictionary construction. The second approach conducts several independent texton-analyses, one per region of interest (ROI), and then merges the several predictions to perform the final diagnosis.

METHODS

Overview of Diagnostic System



Filter Bank



The two procedures proposed in this work are based on the algorithm represented above, differing mainly in the Voxel Selection and Classification phases.

1. Image Filtering – The original image is convolved with a set of filters (shown above). Three different scales were used for each type of filter. Edge, plane and line filters were also used with multiple orientations (61), but only the maximum response was kept for each voxel.

2. Voxel Selection

2.1. Discriminative Selection of Voxels – The most discriminative voxels were selected using a wrapper approach based on the performance of a k-Nearest Neighbors ($k = 11$) classifier.

2.2. Independent Texton-Analysis of ROIs – Seven ROIs were manually labeled by an expert physician. Then, steps 3 and 4 were repeated using all voxels from only one region at a time, which resulted in the generation of seven models for each patient.

3. Dictionary Construction – N_c clusters of the selected filter responses were extracted independently for each class using the k-Means algorithm $(k = N_c)$, generating a dictionary composed by $2 \times N_c$ words or textons.

4. Model Extraction – After labeling all selected filter responses with their closest textons, each subject was represented by an histogram of these labels.

5. Classification – The textons' histograms were used to train and test three classifiers: k-Nearest Neighbors (k-NN) based on χ^2 distance and a Support Vector Machine (SVM) with a linear and a Generalized Histogram Intersection (GHI) kernel.

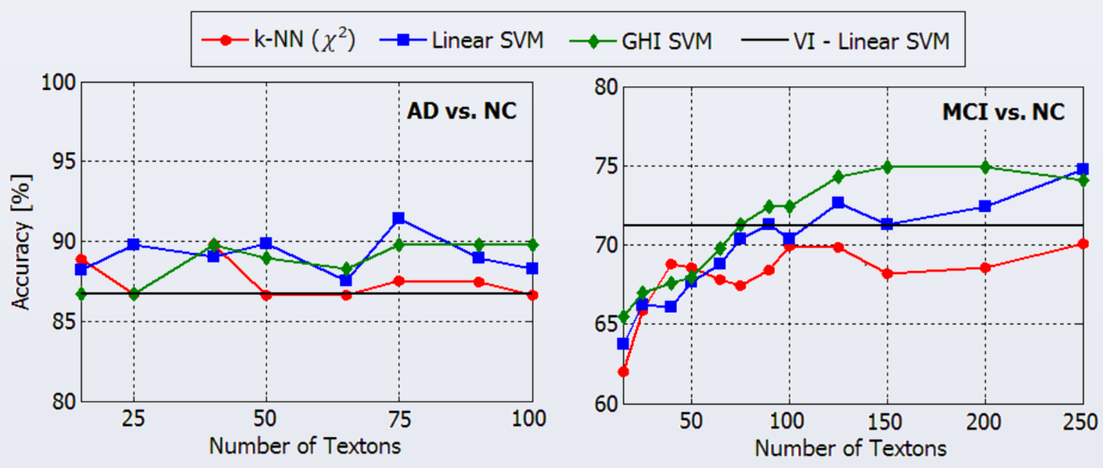
In the case of the independent texton-analysis of ROIs, two schemes were tested: 1) All histograms were concatenated and fed to the above classifiers. 2) Each region was classified independently, and the predictions merged by majority voting.

RESULTS

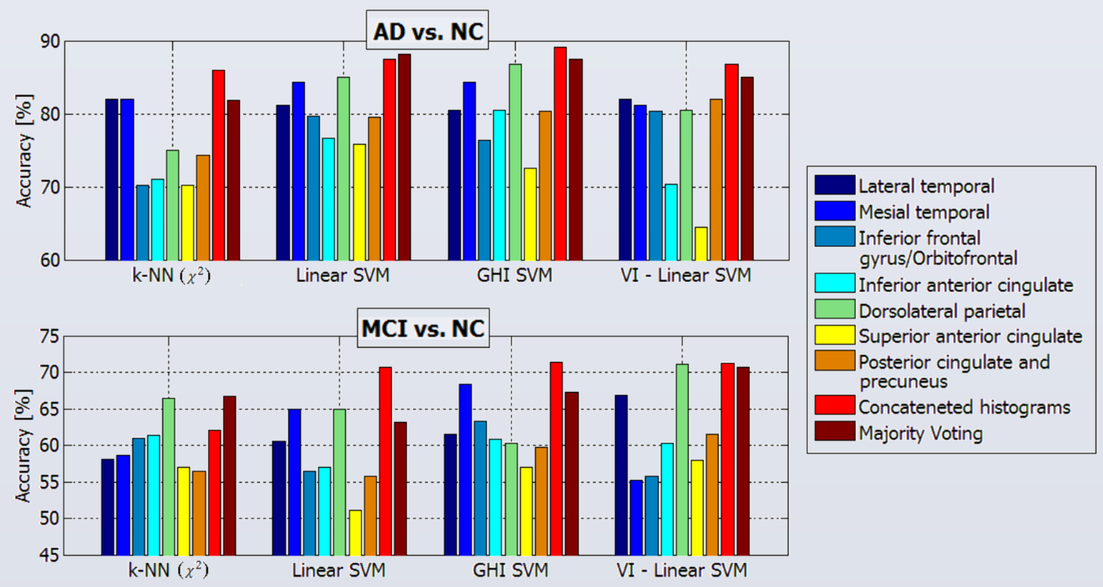
All experiments were conducted using images from the Alzheimer's Disease Neuroimaging Initiative (ADNI) [3].

We compared the two proposed approaches, in the diagnosis of AD and MCI (against normal controls (NC)), with a more standard method which uses the voxel intensities (VI) directly as features. Discriminative selection of VIs was accomplished using the Mutual Information between their values and the class label.

Discriminative Selection of Voxels



Independent Texton-Analysis of ROIs



DISCUSSION AND CONCLUSION

The texton based analysis achieves significantly better performances in the diagnosis of AD and MCI when the most discriminative voxels are selected, in comparison with the VI approach using an equivalent number of voxels.

The number of selected voxels did not affect much the performance of the system, unlike the number of textons. The increased performances in the MCI vs. CN problem for higher number of textons is probably linked with the finer Voronoi partitioning of the filter response space.

Overall performances similar to the VI approach were attained with the texton analysis based on ROIs. Even though the results were slightly better, the differences are not significant, especially in the diagnosis of MCI.

Significant improvements in the diagnostic accuracy were observed in specific regions of interest, such as the Superior Anterior Cingulate in the diagnosis of AD or the Mesial Temporal in the diagnosis of MCI.

REFERENCES

1. P. Morgado, M. Silveira, and J. Marques, "Diagnosis of Alzheimer's disease using 3D local binary patterns," Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization, 2013.
2. M. Varma and A. Zisserman, "A statistical approach to texture classification from single images," International Journal of Computer Vision, vol. 62, no. 1–2, pp. 61–81, 2005.
3. Laboratory of NeuroImaging, UCLA (2013), "Alzheimer's Disease Neuroimaging Initiative," [Online] Available: http://adni.loni.ucla.edu/.

ACKNOWLEDGMENTS

This work was supported by Fundação para a Ciência e Tecnologia (FCT/MCTES) through the ADIAR project (PTDC/SAU-ENB/114606/2009).

Data used in the preparation of this article were obtained from the Alzheimer's Disease Neuroimaging Initiative (ADNI) database. As such, the investigators within the ADNI contributed to the design and implementation of ADNI and/or provided data but did not participate in analysis or writing of this report.